

Application No. 09/774,826
Amendment dated August 8, 2003
Reply to Office Action of May 19, 2003

The following listing of claims replaces all prior versions and listings of claims in the application:

Listing of Claims:

1. (currently amended) A process for removing sulfur from a hydrocarbon comprising:

conveying a feed stream past a first side of a selective solid membrane, wherein said feed stream comprises a feed liquid hydrocarbon and a feed sulfur species, and further wherein said selective solid membrane is constructed from one or more compounds providing greater permeation selectivity for said feed sulfur species than said feed liquid hydrocarbon, and said selective solid membrane contains a facilitated transport liquid selected from the group consisting of amines, hydroxyamines, alcohols, and mixtures thereof;

conveying a sweep stream past a second side of said selective solid membrane;
and

transporting said feed sulfur species from said feed stream through said selective solid membrane in a permeate into said sweep stream, thereby converting said sweep stream to a sulfur-enriched stream and said feed stream to a substantially sulfur-free reject stream containing a primary hydrocarbon product.

2. (original) The process of claim 1 wherein said sweep stream comprises a sweep liquid hydrocarbon.

3. (original) The process of claim 2 wherein said sweep liquid hydrocarbon is selected from the group consisting of naphtha, diesel, cycle oil, and mixtures thereof.

4. (previously amended) The process of claim 1 wherein said feed sulfur species is more membrane permeable than said feed liquid hydrocarbon.

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5. (previously amended) The process of claim 1 wherein said sweep stream is smaller than said feed stream on a weight basis.

6. (original) The process of claim 1 wherein the weight ratio of said sweep stream to said feed stream is below about 0.2.

7. (previously amended) The process of claim 1 wherein said feed liquid hydrocarbon is a refinery hydrocarbon stream.

8. (original) The process of claim 1 wherein said feed liquid hydrocarbon is selected from the group consisting of naphtha, diesel, and mixtures thereof.

9. (original) The process of claim 1 wherein said feed sulfur species is selected from the group consisting of an organic sulfur compound, elemental sulfur, hydrogen sulfide and combinations thereof.

10. (original) The process of claim 9 wherein said organic sulfur compound is selected from the group consisting of thiols, alkylated thiols, thiophenes, alkylated thiophenes, benzothiophene, alkylated benzothiophenes, dibenzothiophenes, alkylated dibenzothiophenes and mixtures thereof.

11. (previously amended) The process of claim 1 wherein said one or more compounds from which said selective solid membrane is constructed is selected from the group consisting of nitrogen compounds, nitrogen oxide compounds, oxygen compounds, sulfur compounds, sulfur oxide compounds, and mixtures thereof.

12. (previously amended) The process of claim 1 wherein said selective solid membrane is more selective for said feed sulfur species than said feed liquid hydrocarbon.

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Claims 13 and 14 are canceled without prejudice.

15. (currently amended) ~~The process of claim 1~~ A process for removing sulfur from a hydrocarbon comprising:

conveying a feed stream past a first side of a selective solid membrane, wherein said feed stream comprises a feed liquid hydrocarbon and a feed sulfur species, and further wherein said selective solid membrane is constructed from one or more compounds providing greater permeation selectivity for said feed sulfur species than said feed liquid hydrocarbon;

conveying a sweep stream past a second side of said selective solid membrane, wherein said sweep stream comprises a decoupling agent species; and

transporting said feed sulfur species from said feed stream through said selective solid membrane in a permeate into said sweep stream, thereby converting said sweep stream to a sulfur-enriched stream and said feed stream to a substantially sulfur-free reject stream containing a primary hydrocarbon product.

16. (original) The process of claim 15 wherein said decoupling agent species is selected from the group consisting of amines, hydroxyamines, alcohols, sulfur compounds, and mixtures thereof.

17. (original) The process of claim 1 further comprising distilling said sulfur-enriched stream to separate said feed sulfur species from said sweep stream.

18. (previously amended) The process of claim 17 further comprising recycling said sweep stream separated from said feed sulfur species to said second side of said selective solid membrane.

19. (previously amended) A process for removing sulfur from a hydrocarbon

comprising:

conveying a feed stream past a first side of a selective solid membrane, wherein said feed stream comprises a feed liquid hydrocarbon and a feed sulfur species, said selective solid membrane is constructed from one or more compounds providing greater permeation selectivity for said feed sulfur species than said feed liquid hydrocarbon, and said selective solid membrane contains a facilitated transport liquid;

transporting said feed sulfur species from said first side into said selective solid membrane in a permeate;

complexing said feed sulfur species with said facilitated transport liquid to form a facilitated transport complex; and

transporting said facilitated transport complex through said selective solid membrane to a second side of said selective solid membrane, thereby converting said feed stream to a substantially sulfur-free reject stream.

20. (original) The process of claim 19 wherein said facilitated transport liquid is selected from the group consisting of amines, hydroxyamines, alcohols, and mixtures thereof.

21. (original) The process of claim 19 further comprising decoupling said at least one sulfur species and said facilitated transport liquid by contacting said facilitated transport complex with a decoupling agent species on said second side.

22. (original) The process of claim 21 wherein said decoupling agent species is selected from the group consisting of amines, hydroxyamines, alcohols, sulfur compounds, and mixtures thereof.

Claims 23-25 are canceled without prejudice.

26. (previously presented) A process for removing sulfur from a hydrocarbon comprising:

conveying a feed stream past a first side of a solid membrane, wherein said feed stream comprises a feed liquid hydrocarbon and a feed sulfur species;

conveying a sweep stream past a second side of said solid membrane, wherein said sweep stream comprises a decoupling agent species;

transporting said feed sulfur species from said feed stream through said solid membrane in a permeate into said sweep stream, thereby converting said sweep stream to a sulfur-enriched stream and said feed stream to a substantially sulfur-free reject stream containing a primary hydrocarbon product.

27. (previously presented) The process of claim 26 wherein said membrane contains a facilitated transport liquid.

28. (previously presented) The process of claim 27 wherein said facilitated transport liquid is selected from the group consisting of amines, hydroxyamines, alcohols, and mixtures thereof.

29. (previously presented) The process of claim 26 wherein said decoupling agent species is selected from the group consisting of amines, hydroxyamines, alcohols, sulfur compounds, and mixtures thereof.

30. (previously presented) The process of claim 27 wherein said decoupling agent species is selected from the group consisting of amines, hydroxyamines, alcohols, sulfur compounds, and mixtures thereof.

31. (previously presented) A process for removing sulfur from a hydrocarbon comprising:

conveying a feed stream past a first side of a solid membrane, wherein said feed stream comprises a feed liquid hydrocarbon and a feed sulfur species and wherein said solid membrane contains a facilitated transport liquid;

transporting said feed sulfur species from said first side into said solid membrane in a permeate;

complexing said feed sulfur species with said facilitated transport liquid to form a facilitated transport complex;

transporting said facilitated transport complex through said solid membrane to a second side of said membrane, thereby converting said feed stream to a substantially sulfur-free reject stream; and

decoupling said at least one sulfur species and said facilitated transport liquid by contacting said facilitated transport complex with a decoupling agent species on said second side.

32. (previously presented) The process of claim 31 wherein said decoupling agent species is selected from the group consisting of amines, hydroxyamines, alcohols, sulfur compounds, and mixtures thereof.

33. (previously presented) The process of claim 31 wherein said facilitated transport liquid is selected from the group consisting of amines, hydroxyamines, alcohols, and mixtures thereof.

34. (previously presented) The process of claim 1 wherein said one or more compounds from which said selective solid membrane is constructed is an organic polymer.

35. (currently amended) ~~The process of claim 1~~ A process for removing sulfur from a hydrocarbon comprising:

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conveying a feed stream past a first side of a selective solid membrane, wherein said feed stream comprises a feed liquid hydrocarbon and a feed sulfur species, said selective solid membrane is constructed from one or more compounds providing greater permeation selectivity for said feed sulfur species than said feed liquid hydrocarbon, and wherein said one or more compounds from which said selective solid membrane is constructed is selected from the group consisting of polyacrylonitrile, polyamide, polysulfone, and combinations thereof;

conveying a sweep stream past a second side of said selective solid membrane;
and

transporting said feed sulfur species from said feed stream through said selective solid membrane in a permeate into said sweep stream, thereby converting said sweep stream to a sulfur-enriched stream and said feed stream to a substantially sulfur-free reject stream containing a primary hydrocarbon product.

36. (currently amended) A process for removing sulfur from a hydrocarbon comprising:

conveying a feed stream past a first side of a selective solid membrane, wherein said feed stream comprises a feed liquid hydrocarbon and a feed sulfur species, and further wherein said selective solid membrane is constructed from one or more compounds selected from the group consisting of polyacrylonitrile, polyamide, polysulfone, and combinations thereof providing greater permeation selectivity for said feed sulfur species than said feed liquid hydrocarbon; and

transporting said feed sulfur species from said feed stream through said selective solid membrane to a second side of said selective solid membrane, thereby converting said feed stream to a substantially sulfur-free reject stream containing a primary hydrocarbon product.

Claims 37 and 38 are canceled without prejudice.

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39. (previously presented) The process of claim 36 wherein said feed liquid hydrocarbon is selected from the group consisting of naphtha, diesel, and mixtures thereof.

40. (previously presented) The process of claim 36 wherein said feed sulfur species is selected from the group consisting of an organic sulfur compound, elemental sulfur, hydrogen sulfide and combinations thereof.

41. (previously presented) The process of claim 40 wherein said organic sulfur compound is selected from the group consisting of thiols, alkylated thiols, thiophenes, alkylated thiophenes, benzothiophene, alkylated benzothiophenes, dibenzothiophenes, alkylated dibenzothiophenes and mixtures thereof.

Claim 42 is canceled without prejudice.

43. (new) The process of claim 1 wherein said sweep stream is diesel.

44. (new) The process of claim 1 wherein said sweep stream is naphtha.

45. (new) The process of claim 15 wherein said sweep stream is diesel.

46. (new) The process of claim 15 wherein said sweep stream is naphtha.

47. (new) The process of claim 26 wherein said sweep stream is diesel.

48. (new) The process of claim 26 wherein said sweep stream is naphtha.

49. (new) The process of claim 35 wherein said sweep stream is diesel.

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50. (new) The process of claim 35 wherein said sweep stream is naphtha.